

****FULL TITLE****

*ASP Conference Series, Vol. **VOLUME**, **YEAR OF PUBLICATION***

****NAMES OF EDITORS****

Introducing the H-Index in Telescope Statistics

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Abstract. This paper analyzes the performance of observatories based on the so-called *h*-index (Hirsch 2005), a new, easy-to-use parameter that quantifies scientists' research impact and relevance. Compared to other bibliometric criteria, like total number of publications or citations, the *h*-index is less biased. Using NASA's Astrophysics Data System (ADS), we investigate the performance of selected observatories, taking into account their specific number of years of operation.

1. Telescope Statistics

At many observatories, librarians are engaged in compiling telescope statistics. These compilations of papers that use data coming from specific observing facilities are needed for a number of purposes, among them assessing the overall impact of facilities, measuring the scientific output from observing programs, and reporting back to funding authorities. Despite the intrinsic dangers (see below), telescope statistics are also often used to compare output among observatories.

Certain bibliometric methods are used frequently in order to evaluate facilities. These methods usually show some advantages as well as specific disadvantages. For instance, counting the total number of publications measures productivity of an observatory, but does not take the importance and impact into account which the papers resulting from the data have generated. In contrast, looking at the total number of citations does measure impact, but the value may be inflated by a few papers that received extraordinarily high numbers of citations. Another method is to investigate contributions to the so-called High-Impact Papers, a term originally coined by Thomson ISI for their database of the most influential papers in specific fields. In astronomy, this name is often used to refer to a study performed by the ST ScI, where the 200 highest cited observational papers are distributed across observatories, based on their actual input of data to these papers (see Madrid, these proceedings). Measuring contributions to High-Impact Papers is more balanced than other bibliometric methods, but the values per observatory are much more difficult to find.

2. The *h*-Index

In 2005, Jorge E. Hirsch of the University of California at San Diego introduced a new measure, the so-called *h*-index (Hirsch 2005). The original aim was to quantify an individual's scientific research output. According to the definition by Hirsch, a researcher with index *h* has *h* papers with at least *h* citations. In other words, index *h* is “the highest number of papers a scientist has that have each received at least that number of citations” (Ball 2005). For instance, if a researcher has written 50 papers, 30 of which have achieved 30 or more citations, his or her *h*-index is 30.

In order to find the *h*-index, one needs a list of all papers fulfilling the criteria under investigation (e.g., written by a specific person or using data from a given facility). This list must be numbered (from 1 to the total number of papers in the list) and ranked by decreasing citation counts, i.e., the paper with the highest number of citations appears on top, that with the lowest number at the bottom. *h* can be found where the number of citations are at least as high as the rank (publication number). See Fig. 1 for an example, using the ADS. Fig. 2 demonstrates that neither a large number of papers with few or no cites (x-axis, right end) nor individual papers with a very high number of citations (y-axis, upper end) influence *h* considerably.

Author Query Results

http://esoads.eso.org/cgi-bin/nph-abs_connect?db_key=AST&qform=AST&sim_query=RSS Google

Author Query Results

Golimowski, D. A.; Finkbeiner, D.;
Gunn, J. E.; Hennawi, J.; Ivezić, Z.; and
19 coauthors

Citations

57	2004ApJ...615L101B	57,000	11/2004	A	E	F	X	R	C	U	H
	Balogh, Michael L.; Baldry, Ivan K.; Nichol, Robert; Miller, Chris; Bower, Richard; Glazebrook, Karl										
58	2001ApJ...549..820C	57,000	03/2001	A	E	F	X	D	R	C	S
	Couch, Warrick J.; Balogh, Michael L.; Bower, Richard G.; Small, Ian; Glazebrook, Karl; Taylor, Melinda									N	U
59	2004AJ...127.2455A	55,000	05/2004	A	E	F	X	D	R	C	S
	Abraham, Roberto G.; Glazebrook, Karl; McCarthy, Patrick J.; Crampton, David; Murowinski, Richard; Jørgensen, Inger; Roth, Kathy; Hook, Isobel M.; Savaglio, Sandra; Chen, Hsiao-Wen; and 2 coauthors										N
60	2002MNRAS.333..279L	54,000	06/2002	A	E	F	G	X	R	C	S
											U

Paper number

Figure 1. How to find the *h*-index with the ADS: the highest paper number that has at least as many citations.

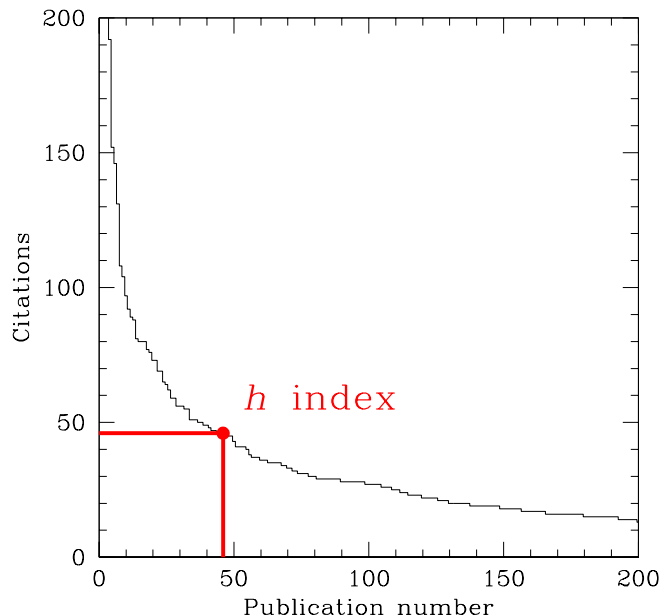


Figure 2. h -index: where the rank (counted publication number) and the number of citations are the same.

3. Applying h to Observatories

The authors assumed that what works well for individual researchers should also be applicable to facilities, and applied Hirsch's h -index to observatories. Our study includes papers from the CFHT, HST, Keck, ESO VLT and Gemini. This selection is somewhat arbitrary as it was largely defined by the question of which observatories provide easy access to bibcodes of papers resulting from their data.

Before we continue, we would like to issue a word of warning: it is very difficult, if not impossible, to compare statistics across observatories in a fair, unbiased way. Some of the reasons originate from the procedures – the criteria for inclusion of papers are not uniform so that the contents of the resulting bibliographies vary. Also the methodologies applied for building telescope bibliographies vary among institutions; they can range from electronic searching whatever sections of relevant journals are available online to scrutinizing journal issues on paper (with the non-exclusively electronic approach still leading to a higher completeness, see Stevens-Rayburn & Grothkopf, these proceedings). Other difficulties result from the differences among facilities: we only have to think of ground-based versus space-based observatories, different apertures, different wavelengths etc. Therefore, our study is meant as a first introduction of the h -index in the evaluation of facilities; further studies will be needed to fine-tune the methodology.

4. Our Sample

As mentioned above, our sample includes those telescope bibliographies to which we had comparably easy access. These are the following observatories and ranges of years of coverage:

Table 1. Total sample included in our study.

CFHT	1980 - 2005
HST	1991 - 2005
Keck	1996 - 2005
ESO VLT	1999 - 2005
Gemini	2000 - 2005

For uniformity, we ended the sample with publication year 2005 for all facilities.

For the years given above, we collected all bibcodes of papers included in the observatories' telescope bibliographies as follows: for CFHT and HST, bibcodes were retrieved through the ADS by using the filter "Select References In:" CFHT and HST, respectively, sorted by citation count. (This filter also allows to select ESO Telescopes; however, this feature does not discriminate between ESO VLT and ESO La Silla papers. Such a distinction is only possible through the ESO Telescope Bibliography, see below.) Keck bibcodes were extracted from the references provided in their Science Bibliography (<http://www2.keck.hawaii.edu/library/1996.htm> through 2005.htm). Gemini bibcodes and numbers of citations were kindly provided by the Gemini librarian. Bibcodes of papers using ESO VLT data are available through the ESO Telescope Bibliography (<http://www.eso.org/libraries/telbib.html>).

Individual citations per paper were retrieved from the ADS and (in the case of Keck, VLT and Gemini) listed in decreasing order in an Excel spreadsheet so that the h -index could be obtained. For CFHT and HST, the ADS very conveniently provides the h -index as described above.

Computing the h -index for all years included in our study led to the following results: CFHT (1980 - 2005): 94; HST (1991 - 2005): 131; Keck (1996 - 2005): 105; ESO VLT (1999 - 2005): 69; Gemini (2000 - 2005): 26. Note that in order to be meaningful, h needs to be complemented with a parameter that normalizes based on the number of years of operation!

5. h -Index and m Parameter

Obviously, the telescopes we investigated did not come online at the same time, but over a period of 20 years (see Table 1). Accordingly, some had more, others much less time to gather citations. We therefore applied a measure to normalize results based on the time that has lapsed since the first papers were published: the m parameter, also introduced by Hirsch (2005). In simple words, m is h divided by the number of years of operation. For instance, if h is 20 after 20

years, m is 1 ($20 : 20 = 1$); if h is 40 after 20 years, m is 2 ($40 : 20 = 2$) etc. The higher m is, the better.

In order to retrieve m easily for our sample, we introduced a “Years since first paper” column in our table and divided h by the number of years indicated in this column. The results are shown in Table 2 and Fig. 3.

Table 2. h -index and parameter m computed for all publication years included in our study.

Observatory	Years	Years since first paper	h	m
CFHT	1980 - 2005	25	94	3.76
HST	1991 - 2005	14	131	9.36
Keck	1996 - 2005	9	105	11.67
ESO VLT	1999 - 2005	6	69	11.5
Gemini	2000 - 2005	5	26	5.2

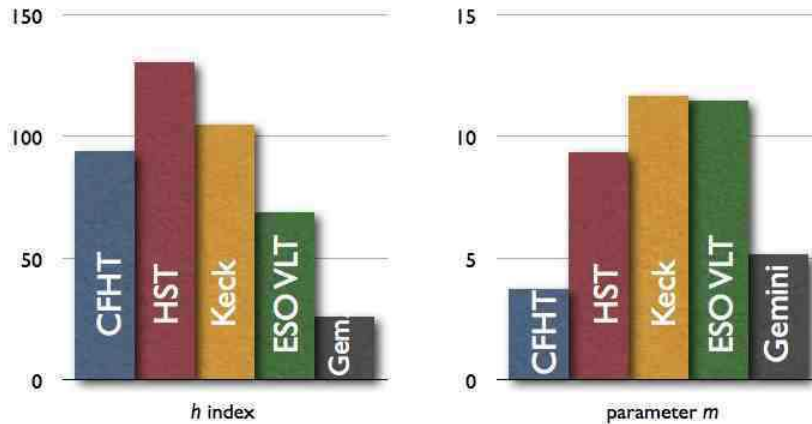


Figure 3. h -index and parameter m of our entire sample (see Table 1). Note that h needs to be complemented with m to be meaningful.

6. h and m for Identical Range of Years

In order to focus on common years of operation, we went on to investigate those telescopes for which we had bibliographies stemming from the same period, namely CFHT, HST and Keck. For these facilities, we limited the range of years

to 1996 - 2005 and again computed h and m . The results are given in Table 3. While h and m were vastly different when looking at all years, the values take on a much more similar shape for the subset of years (even though on a different scale, see Fig. 4), with HST being the leader, followed by Keck and CFHT. In comparison to results of our entire study (from the first papers onwards), m -values of the selected years 1996 to 2005 have increased for the two older telescopes (CFHT and HST), suggesting that the metric doesn't flow as linearly as one might desire, but rather new instrumentation or more creative observing proposals can positively affect the citation rates for older observatories.

Table 3. h -index and parameter m computed for the years 1996 - 2005.

Observatory	Years	Years since first paper	h	m
CFHT	1996 - 2005	9	62	6.89
HST	1996 - 2005	9	118	13.11
Keck	1996 - 2005	9	105	11.67

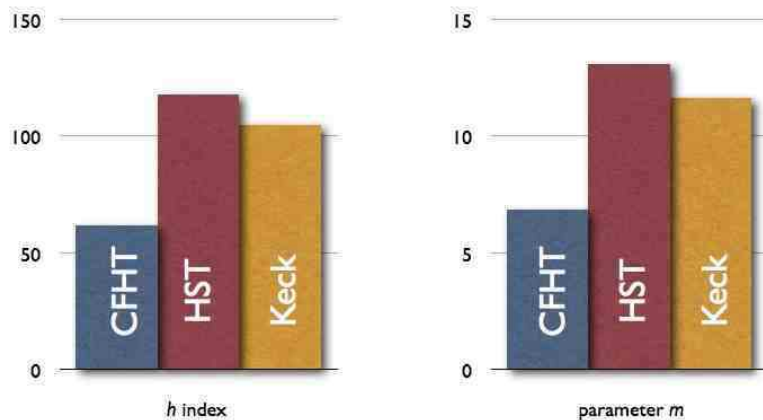


Figure 4. h -index and parameter m of selected telescope bibliographies for the years 1996 - 2005.

For the HST, we conducted another brief study in order to find out if and how h and m change over time. For all HST papers, going back to the first ones published after the launch in 1991, and including the first six months of 2006, we found $h = 132$ and $m = 8.8$. If the early papers are left out and the range of years taken into account starts after the first servicing mission (COSTAR) in 1994, these values change to $h = 128$ and $m = 10.66$. STIS and NICMOS were

installed in 1998, and h and m for the years 1998 to mid-2006 are 103 and 12.87, respectively. This indicates that also the m parameter can be misleading with regard to telescopes that continue to be refurbished over time. Both h and m therefore should be used in telescope statistics with greatest care.

7. Conclusions

There are some clear advantages of the h -index which may make it suitable also for telescope statistics:

- it combines productivity and impact
- it is easy to find using the ADS
- it is not sensitive to extreme values

On the other hand, as with all statistics, one has to apply utmost attention when applying the h -index, in particular because

- it is determined by the number of years of operation and
- it needs to be combined with the m parameter for comparison across facilities

In this paper, we have shown how the h -index and the m parameter can be used in telescope statistics. However, it is important to note that one single parameter is never enough to represent the complex reality, and a narrowly based approach might lead to incorrect results and wrong interpretations.

Acknowledgments. The authors wish to thank Peggy Kamisato (Keck Observatory), Liz Bryson (CFHT) and Xiaoyu Zhang (Gemini Observatory) for providing access to their telescope bibliographies, either personally or through the ADS. We are very grateful to Juan Madrid (ST ScI), Don Stevens-Rayburn and Sandra Savaglio (MPE) for extracting and comparing Keck bibcodes. Special thanks go to Elizabeth Fraser (ST ScI) and Angelika Treumann (ESO) for maintaining the ST ScI and ESO telescope bibliographies.

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